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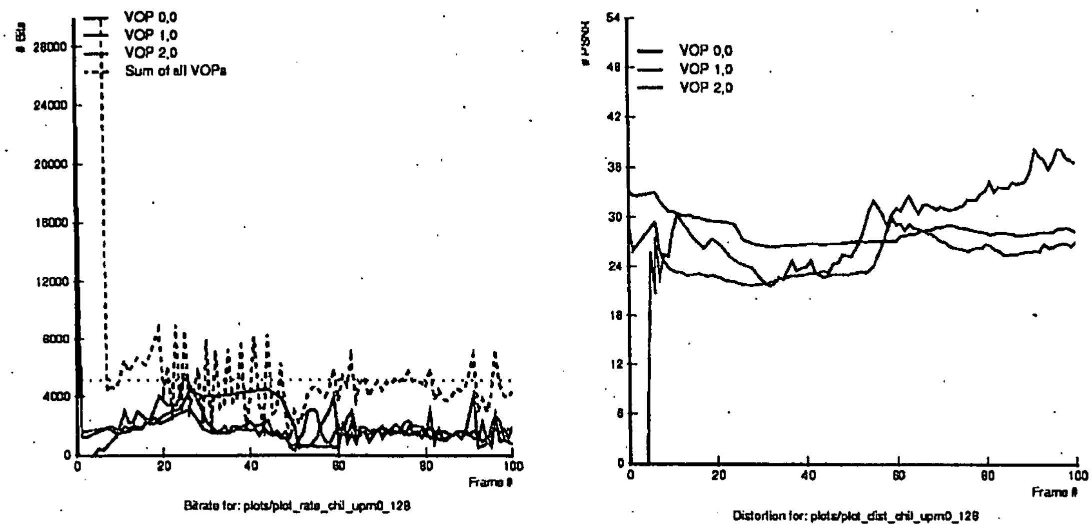


Figure 3: Rate and distortion for sequence CHILDREN coded with independent control at 128 kbit/s.

4.2 Overall Quality Optimization

The parameter sets which have been selected according to the before mentioned preferences are presented in the following tables:

News		α_i-Set 1	α_i-Set 2
VO 0	Background	1	0.5
VO 1	TV screen	1	0.8
VO 2	Two speakers	1	1.0
VO 3	Static MPEG logo	1	0.3

Children		α_i-Set 1	α_i-Set 2
VO 0	Background	1	0.3
VO 1	Two playing children	1	1.0
VO 2	Moving MPEG logo	1	0.5

In the sense that higher weights for the distortion induce the algorithm to choose lower quantization parameters (⇒ better quality) and vice versa. The results for this tests are:

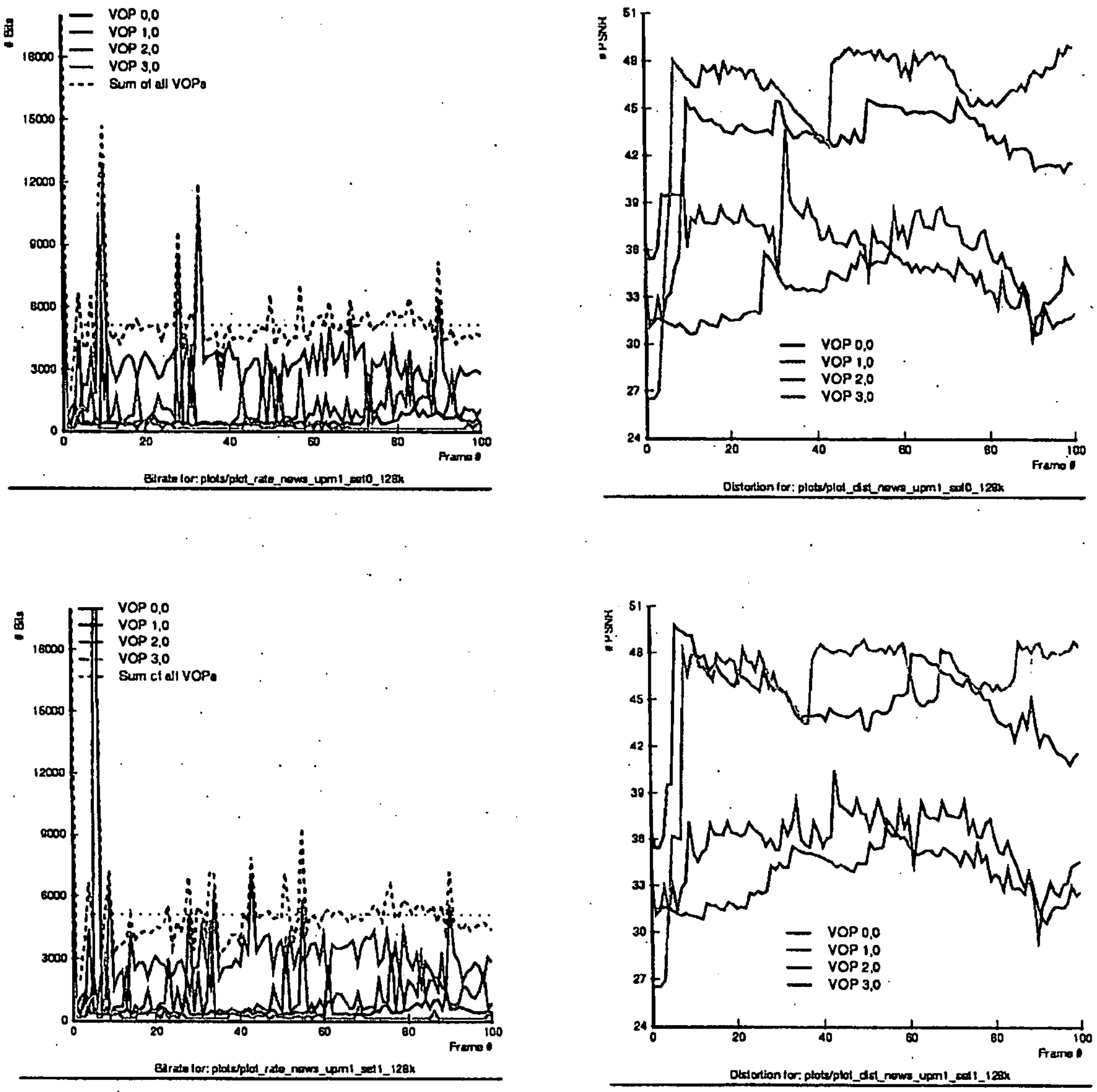
	News				**Children**			
VO	α_i	64K	128K	256K	α_i	64K	128K	256K
0	1	35.74	43.14	48.05	1	26.56	26.68	28.57
1	1	31.62	36.37	38.99	1	22.74	24.31	29.26
2	1	30.34	33.24	39.98	1	22.09	25.71	30.19
3	1	44.94	45.83	45.33				
∅		35.66	39.65	43.09		23.79	25.57	29.34

	News				Children			
VO	α_i	64K	128K	256K	α_i	64K	128K	256K
0	0.5	36.98	44.72	46.77	0.3	26.56	26.71	27.37
1	0.8	31.32	35.80	39.72	1	22.74	25.39	30.62
2	1	30.42	33.55	40.28	0.5	22.06	24.52	29.07
3	0.3	44.22	45.84	45.34				
Ø		35.74	39.98	43.03		23.79	25.54	29.02

In comparison to the average results of the independent control, we gain 2-6 dB for **News** while the quality for **Children** decreases (because the independent control exceeds the target bit rate). This is almost the same for the second parameter set. Taking into account that these results (set 2) are obtained simulating a case which could be real, the effects are significant, although more visible for higher bit rates. Comparing them with set 1 for sequence **News**, the PSNR of the most important object (VO 2) increases (0.3 dB for 128 and 256 kb/s) due to the (relative) higher parameter, while the values of the others in general decrease. The quality of VO 1 should also increase a little because its weight is relatively high, but below 256 kb/s this is not achieved because it requires a high bit amount (moving TV screen).

For VO3, a lower quality is only achieved for 64 kb/s due to the fact that it is a still object which can be coded perfectly already with a very small bit amount. Also, as it is the last coded object, its bit budget consists of the rest of bits which remains after coding of the other objects and can differ significantly. This can be observed in the fluctuating PSNR curve for VO 3 in figures 2 a) and b), which show the results for 128k. As it is the static logo, it could be coded with constant quality at a low rate (see figure 2, independent control). There are also some effects which are not visible in the table of average PSNR values, e.g. the PSNR of VO 1 is higher in the first half and lets space which unfortunately is not used by VO 2 but VO 0.

For the sequence **Children** the effects are visible more clearly, i.e. the average PSNRs are adapting better to the weights. The PSNRs of objects with lower weights are lower and the one of VO 1, which keeps the weight one, is higher, even more with a higher target rate. Comparing figures 2 a) and b), it can be observed how the distortion curve of VO 1 increases in the second half of the sequence over the one of VO 0.



b)

Figure 3: Global optimization for the sequence NEWS tested at 128kb/s. Above: Parameter set 1, below: parameter set 2.

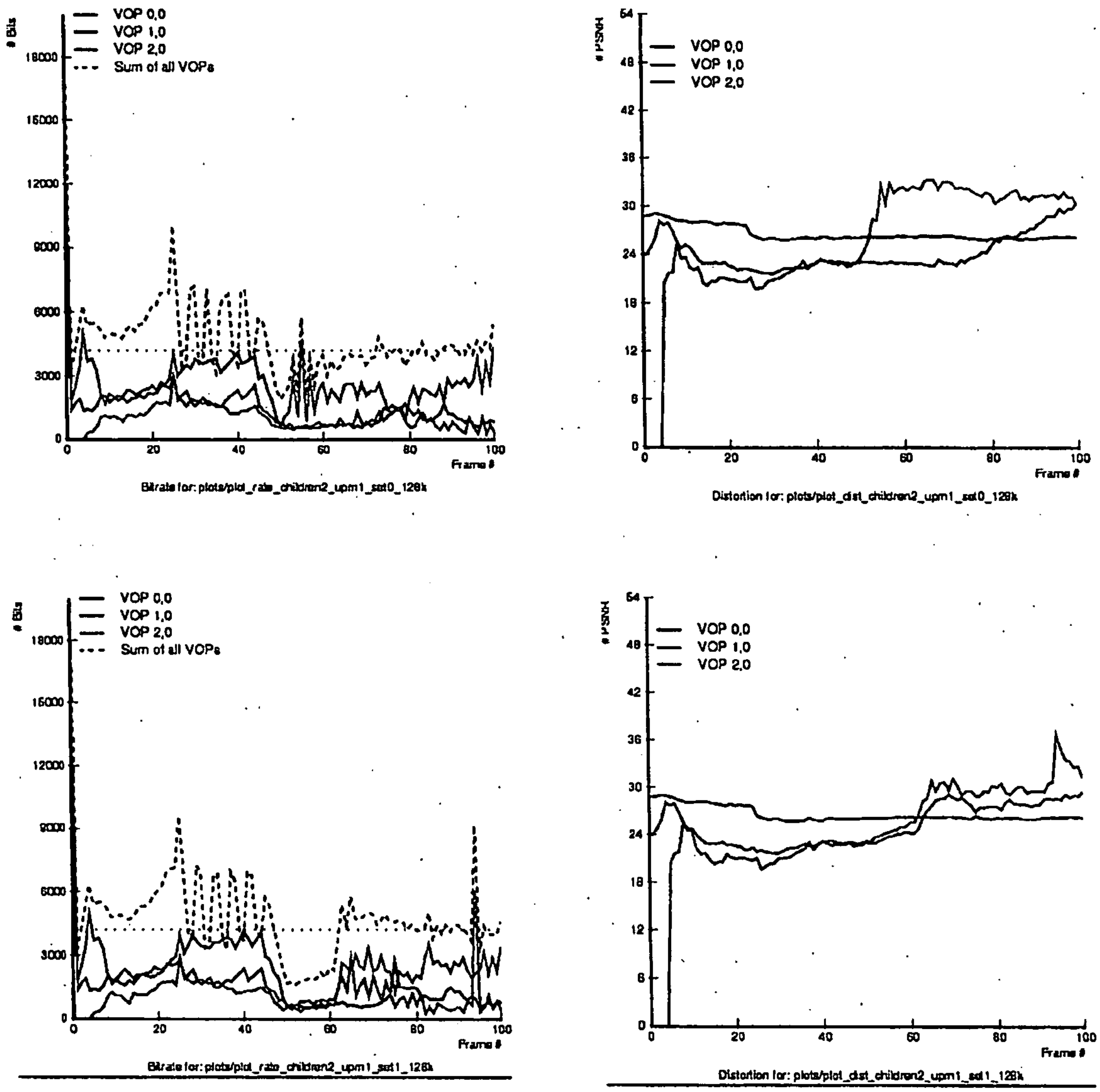


Figure 3: Global optimization for the sequence CHILDREN tested at 128kb/s. Above: parameter set 1, below: parameter set 2.

4.3 Priority List

As described in section 2.2 for this algorithm an objective list has to be provided. To simulate the formerly mentioned conditions, this list has been set as follows:
$\{(2, d_{target}), (1, d_{target}), (0, d_{target}), (3, d_{target})\}$
which also specifies the second list of hierarchies as it is realized in the current implementation.

News		position in list p_i	d_{target} [dB]
VO 0	Background	2	35.0
VO 1	TV screen	1	35.0
VO 2	Two speakers	0	35.0
VO 3	Static MPEG logo	3	35.0

Children		position in list p_i	d_{target} [dB]
VO 0	Background	2	35.0
VO 1	Two playing children	0	35.0
VO 2	Moving MPEG logo	1	35.0

Results:

	News				Children			
VO	p_i	64K	128K	256K	p_i	64K	128K	256K
0	2	35.07	35.12	35.13	2	26.43	26.51	27.51
1	1	29.23	33.46	32.99	0	22.69	26.34	31.53
2	0	33.14	36.89	39.16	1	21.98	22.73	25.97
3	3	44.45	46.11	46.77				
∅		35.47	37.89	38.51		23.7	25.19	28.34

The here obtained average PSNRs are not so high as the former ones, but they still outperform the ones of the independent control.

The table shows that this algorithm is more useful than the former one if a strictly hierarchical coding is desired. VO 1 and VO 2 in **News** and **Children** e.g., are now coded in the desired order. As before with the minimization algorithm, the least important object does not release many bits, due to the small bit amount it needs, and, as in the case of **Children**, due to the order of coding. As the least important VOP is coded first, its quantization parameter is chosen with respect to the estimated bit rates of the other objects, which can not be so exact, because the *mads* are not known, i.e. this example shows clearly how the sequential implementation reduces the flexibility of the algorithms.

Nevertheless, figure 4 a) shows how good the desired order of objects 1 and 2 is fulfilled for sequence **News**. Unless the resulting average PSNR values are quite good, the algorithm forces too much the good quality (and the achievement of the target PSNR) for the most important object, s~~o that the buffer fills up and has to be emptie~~d (the buffer control automatically regulates the target rate) which leads to very unstable results. In figure 4 b), the curves show that for the sequence **Children** the desired order is nearly obtained. VO 1 is coded with best quality and higher than VO 2 and VO 0. The curve of VO 2 achieves in the second half to be situated above the one of VO 0, which, as it represents the background, does not loose much quality because it is already coded with very few bits. The desired target PSNR of 35.0 dB almost could be reached due to the available bit rate.

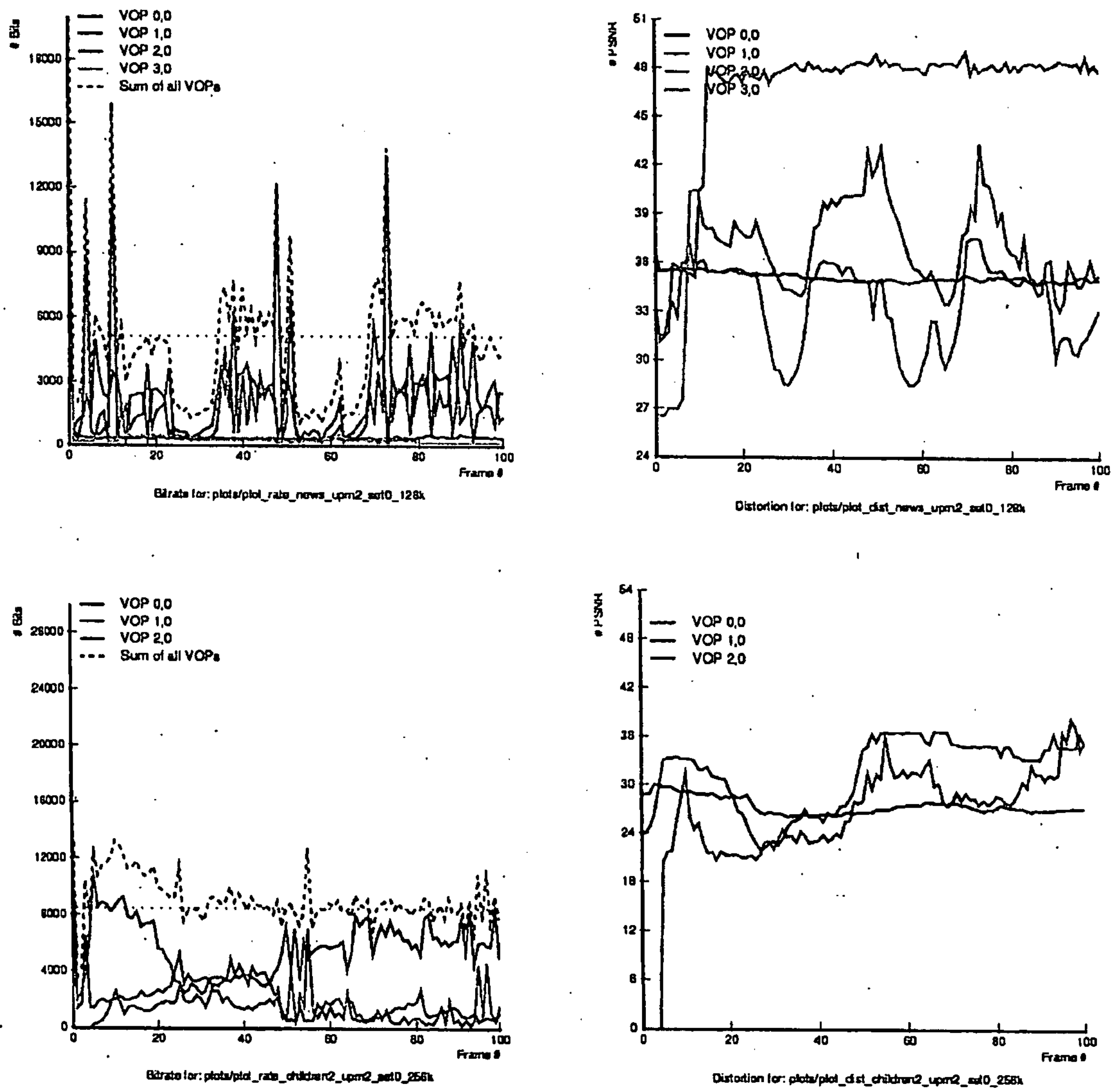


Figure 4: Priority based optimization for the sequences NEWS (above) and CHILDREN (below) tested at 128kb/s and 256kb/s respectively.

4.4 Constant Ratios

The parameter set for the ratio values according to the former hierarchy has been obtained in the following manner:

As $$PSNR_2 = \beta_2 PSNR_1'$$

and : $$PSNR = 20\log_{10}\left(\frac{255}{d}\right)$$

$$PSNR_2 = 20\log_{10}\left(\frac{255\cdot\beta_2}{d_2}\right) = PSNR_1 + 20\log_{10}(\beta_2)$$

So we set up possible differences of the PSNRs in relation to the most important object and calculated the corresponding β_i as:

News		β_i	±dB
VO 0	Background	1.12	-1
VO 1	TV screen	1.4	-3
VO 2	Two speakers	1	0
VO 3	Static MPEG logo	0.32	+10
Children		β_i	±dB
VO 0	Background	0.79	+2
VO 1	Two playing children	1	0
VO 2	Moving MPEG logo	1.26	-2

These tests also were made with a reference set ($\beta_i = 1$). The following tables show the corresponding results:

	News				Children			
VO	β_i	64K	128K	256K	β_i	64K	128K	256K
0	1	34.35	36.24	38.95	1	34.05	30.79	29.21
1	1	31.37	35.44	38.55	1	22.36	27.13	28.74
2	1	29.5	35.29	38.91	1	24.84	26.21	28.53
3	1	39.17	39.61	41.95				
Ø		33.6	36.65	39.59		27.08	28.04	28.83

	News					Children				
VO	β_i	±dB	64K	128K	256K	β_i	±dB	64K	128K	256K
0	1.12	-1	35.25	36.63	35.12	0.79	+2	34.09	31.02	29.54
1	1.4	-3	31.11	33.29	33.15	1	0	22.87	26.17	27.49
2	1	0	30.16	35.26	36.2	1.26	-2	24.98	24.44	25.81
3	0.32	+10	40.04	44.02	45.04					
Ø			34.14	37.3	37.38			27.31	27.21	27.61

As can be seen, the algorithm works very well for the case of equal distribution, the higher the target bit rate the better. For 256kbit/s, the obtained distortions are almost equal. The results obtained with the second parameter set are not so favourable for lower bit rates, but for 256kbit/s the desired ratios are obtained nearly exactly for both sequences. The fact that the desired ratios are not achieved in every case is due to the characteristics of the objects in the sequences. I.e. the least important objects are always easier to code with a good quality, because in general they does not move, change their shape etc. So, unless one of the other objects requires a big bit amount, the quality remains high. To show this, we also present the graphic for the quantization parameter in figure 5.

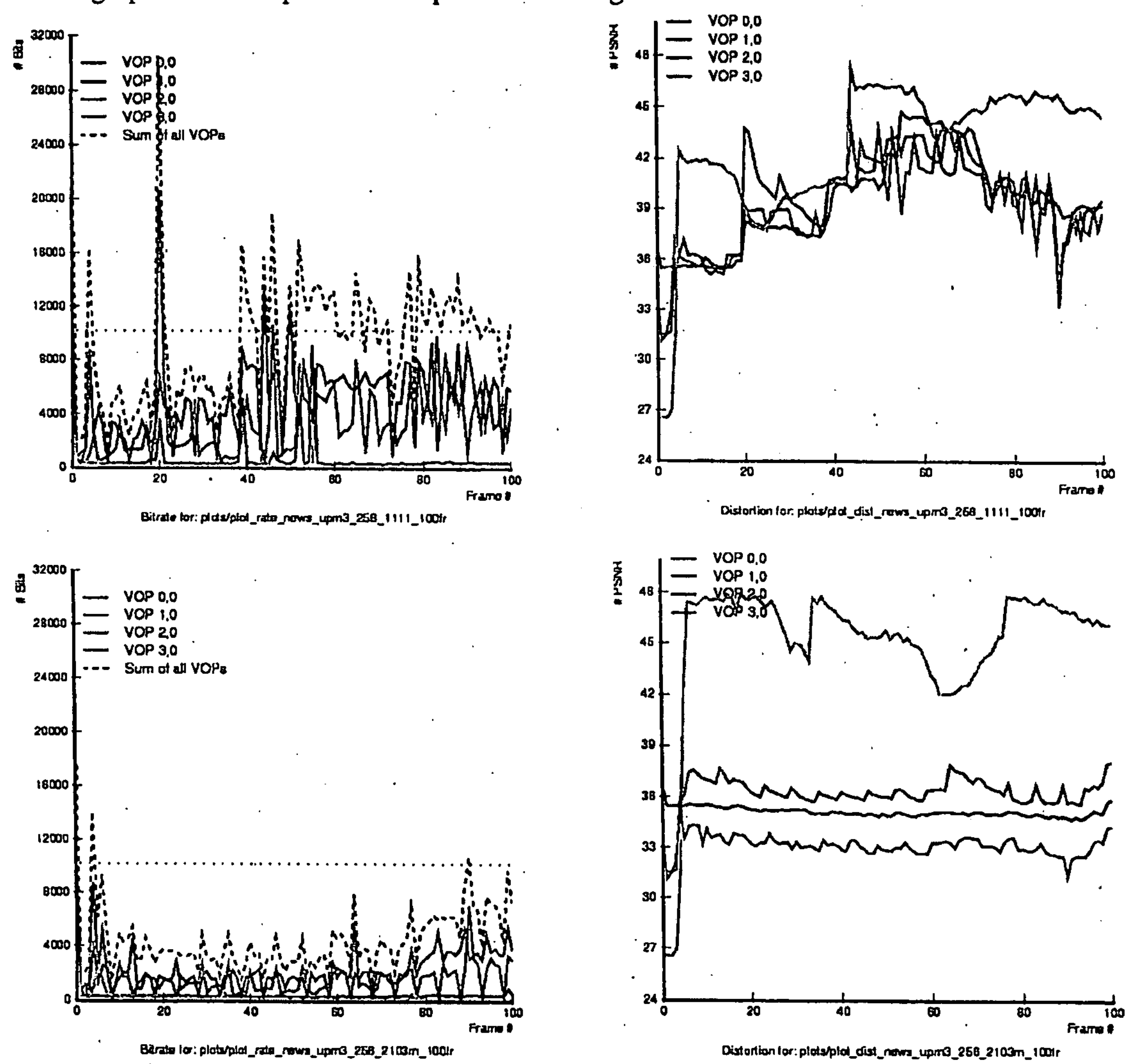


Figure 4: Rate and distortion for sequence NEWS coded at 256kbit/s with parameter set 1 (above) and parameter set 2 (below).

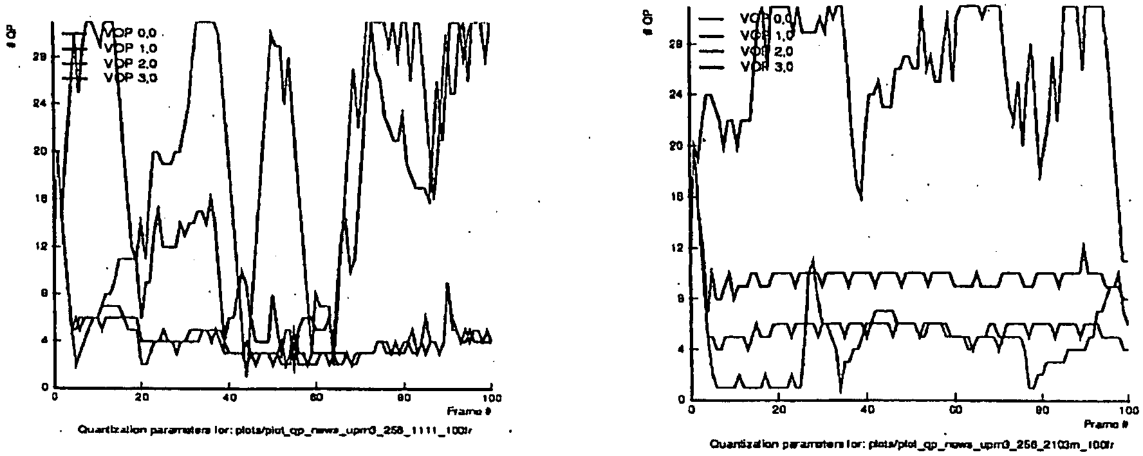


Figure 5: Evolution of quantization parameters for sequence NEWS, left: parameter set 1, right: parameter set 2

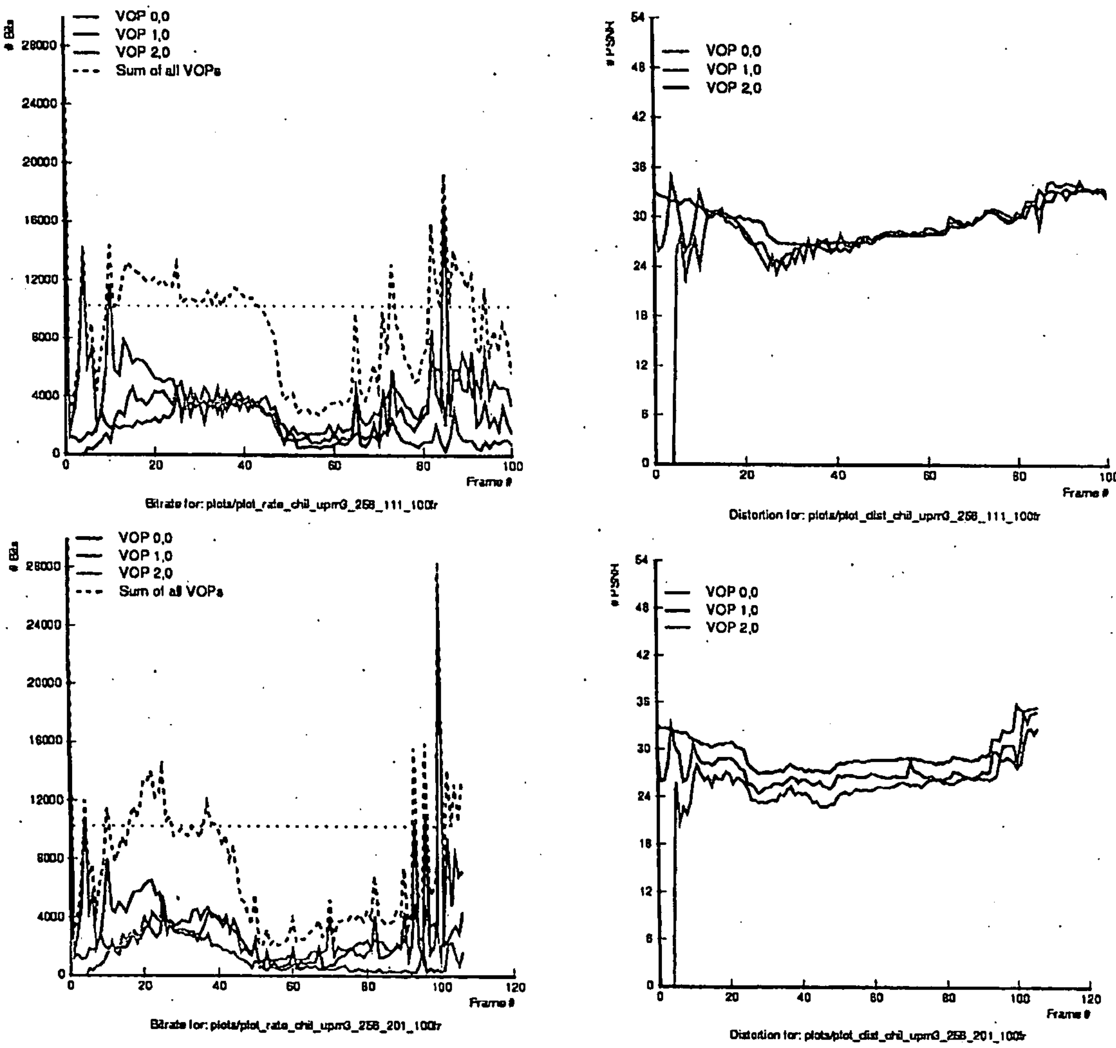


Figure 6: Rate and distortion curves for sequence CHILDREN at 256kbit/s. above: parameter set 1, below: parameter set 2.

5 Conclusions

In this report we have presented three new multi-object based bit allocation criteria and corresponding algorithms for MPEG-4. They provide an efficient utilization of the target bit amount and user interaction because of their capability to guarantee certain conditions on the absolute or relative coding qualities of the objects.

In general, the results are good, as the criteria are fulfilled in most of the cases. The best behaviour corresponds to the third presented algorithm which codes the objects regarding to certain distortion ratios. The overall minimization algorithm has also a good performance, the algorithm based on priority lists still does not fulfil our expectations and will be improved.

In general the following difficulties appear:

- The quantization parameters are too coarse to allow the obtainment of exact ratios, because the bits and distortions corresponding to one unit difference can be very high and so extremely "discrete".
- Exact source modelling is difficult for objects which are still and then changing abruptly so that the model, due to obtaining similar data during a long period, provides wrong estimation values.
- Static and minimal changing objects have got a special behaviour. Here it is possible to code them qualitatively high with a small bit amount, so that it is nearly impossible to reach certain ratios to other objects or to show that the are really coded with lower priority.
- The knowledge of the prediction errors of all VOs is very important for correct global distribution of the target bit amount but can not be provided by the current structure of the VM implementation.

Summarizing, the proposed work is promising unless there are still some tasks open to solve. Interesting directions of improvement are:

- Combine the here proposed bit-allocation criteria with the macroblock-level bit-allocation techniques proposed in MPEG-4 [3].
- Incorporate some features of other models proposed in MPEG-4 [3]

Besides, the behaviour of the algorithms with other rate control algorithms (i.e., procedures to provide the total number of bits for all the VOPs) has to be studied.

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